2.93 A closed tank is filled with water and has a 4-ft-diameter hemispherical dome as shown in Fig. P2.93. A U-tube manometer is connected to the tank. Determine the vertical force of the water on the dome if the differential manometer reading is 7 ft and the air pressure at the upper end of the manometer is 12.6 psi.

For equilibrium,
\[ \sum F_{\text{vertical}} = 0 \]
so that
\[ F_D = pA - W \]

where \( F_D \) is the force the dome exerts on the fluid and \( p \) is the water pressure at the base of the dome.

From the manometer,
\[ p_A + \rho_f (7 \text{ ft}) - \rho_{H_2O} (4 \text{ ft}) = p \]

so that
\[ p = (12.6 \frac{\text{lb}}{\text{in}^2}) (144 \frac{\text{in}^3}{\text{ft}^2}) + (3.0) (62.4 \frac{\text{lb}}{\text{ft}^3}) (7 \text{ ft}) - (62.4 \frac{\text{lb}}{\text{ft}^3}) (4 \text{ ft}) \]
\[ = 2880 \frac{\text{lb}}{\text{ft}^2} \]

Thus, from Eq. (1) with volume of sphere = \( \frac{4}{3} \pi \text{(Diameter)}^3 \)
\[ F_D = (2880 \frac{\text{lb}}{\text{ft}^2}) (\frac{\pi}{4}) (4 \text{ ft})^2 - \frac{1}{2} \left( \frac{\pi}{6} (4 \text{ ft})^3 \right) (62.4 \frac{\text{lb}}{\text{ft}^3}) \]
\[ = 35,100 \text{ lb} \]

The force that the vertical force that the water exerts on the dome is \( 35,100 \text{ lb} \).